ON WATER FROM THE ROOTS OF THE RED MALLEE (*EUCALYPTUS OLEOSA*).

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The use for drinking purposes of the water or sap which can be obtained from the roots and stems of plants, has been described by many observers. Eyre* mentions how dependent he was on this source of supply obtained by the aboriginals of his party, in the course of his famous journey along the Great Australian Bight, in 1841. Mueller† refers to the copious store of water in the roots of the Mallee. Cairns‡ has some very interesting observations on the same subject. In the course of a lengthy paper, "Effects of Forest Vegetation on Climate,"§ Rev. W. B. Clarke mentions the occurrence of such water and its use by aboriginals and others. Magarey,‖ in a valuable paper in which a great deal of information is gathered, details a large number of Australian plants which are of value in this connection, and which, in parts of the interior where water is scarce or absent, enable the aboriginals to exist.

In numerous other works mention is made of this source of supply of drinking water, but I have been unable to find any adequate report of a chemical examination. Doherty¶ gives a partial analysis of a sample from a species of *Vitis* growing at Tweed River, New South Wales, in which he found 39 grains total solids per gallon, of which 11 grains were inorganic, and 28 grains organic, chiefly tannin. This is equivalent to 55·8 parts total solids, of which 15·7 are inorganic, and 40·0 tannin per 100,000.

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* Central Expeditions into Australia, i., p.350.

† Fragments, ii., p.57.

‡ Trans. Phil. Inst. Viet., iii.

§ Journ. Roy. Soc. N. S. Wales, x., pp.179-235.

‖ Rep. Aust. Assn. Adv. Science, vi., p.647.

¶ Rep. Aust. Assn. Adv. Science, vii., p.335.

At the meeting of this Society in September, 1918, Mr. Fletcher exhibited specimens of the water-storing roots of the Red Mallee (*Eucalyptus oleosa*), and of the water obtained therefrom, which had been sent to him from Fowler's Bay, South Australia, through the good offices of Messrs. G. Murray, T. Gill, C.M.G., and H. S. Crummer. Mr. Fletcher kindly gave me the water for chemical examination, and I desire to thank him and the gentlemen named for the opportunity of conducting so interesting an investigation.

When the water is freshly extracted, it is stated to be colourless and practically without taste, and furnishes a cool refreshing drink. It is obtained by cutting lengths of the roots, and allowing them to drain into a vessel. When the tightly-corked sample reached me, it had been in the bottles several months, and had a pale brown colour, which darkened considerably soon after the bottles were opened. When I examined the sample it had a slight flavour, resembling that of water in which leaves had been soaked or that from a peaty source, but was quite palatable. It was neutral to litmus. The figures below give the results of the analysis. For comparison, I have put in the average of a number of representative analyses of soil waters obtained by Morgan at Michigan Agricultural College, U.S.A.*

These samples were obtained by packing the soil firmly into an iron cylinder, screwing on a tightly-closing lid, and pumping kerosene in on top. The kerosene displaced the soil solution, which was collected through a small pipe at the bottom. Morgan states his results on a different scale and system, but for purposes of comparison I have calculated them to the basis used by me.

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* Michigan Agricult. Coll. Tech. Bull. No. 28, Oct. 1916.

Results of analyses of Red Mallee root-water and of soil-solution, in parts per 100,000:—

	Root water.	Soil Solution (American).
Potash (K_2O)	4·25	5·66
Soda (Na_2O)	7·03	
Lime (CaO)	4·48	11·45
Magnesia (MgO)	1·44	11·97
Chlorine (Cl)	5·88	
Sulphuric anhydride (SO_3)	1·79	
Phosphoric oxide (P_2O_5)	0·43	0·69
Undetermined and loss	0·22	13·03
	25·52	42·80
Less oxygen equivalent to chlorine ...	1·32	
Total salts	24·20	
Organic matter	42·40*	32·90
Total solids	66·60	75·70
Specific gravity...	1.0003	1·0007

* Chiefly tannin.

In the root-water analysis, the carbon dioxide present in the ash, being produced during incineration, is extraneous, and has been deducted. The chlorine was determined in the water direct. The sample was insufficient to enable me to investigate the nature of the tannin, of which the organic matter mainly consisted.

Unfortunately, the American report does not take cognisance of soda, chlorine or sulphuric anhydride. The organic matter in the soil water would probably consist principally of humus. Taking the figures for soil solution as being representative, it is interesting to note how the plant has selected the substances absorbed. Thus potash and lime are taken up in greater relative proportion than magnesia. This selective action is well known. A striking illustration is furnished by marine plants, which, though bathed in a medium containing enormous relative proportions of soda and magnesia, take up very little of these substances, but select the much less abundant potash. Although land-plants do possess a very decided power of selection, we have evidence that this is to

some extent overcome by the osmotic pressure of substances in the soil solution, and a plant may be compelled to take up a larger amount of substances like soda or magnesia than it requires, and which may be decidedly harmful. Such a case is furnished in my own experience by the growth of sugar-cane on soil infiltrated with brackish water, on certain parts of the Clarence River, New South Wales, and on what is known as Tiri land in Fiji—low-lying land subject to inundation with sea-water. In such cases, quite excessive amounts of chlorides are found in the juice when the cane is crushed.

Another interesting point which requires bearing in mind in case of further investigation of the water from plants, is that brought out by Professor H. H. Dixon*, as to the variation in concentration in different parts of the plant. Dixon finds that the concentration of solids is greatest in the sap from the roots, and becomes less in the upper parts of the plant. This was determined by the electrical conductivity and freezing-point methods in samples of sap obtained by centrifuging pieces of the roots and stems. The figures obtained by both methods are proportional to the amount of dissolved substance present, and are in close agreement. It was found in the case, for instance, of *Acer pseudoplatanus*, that the sap in the branches at a height of 30 feet had only two-thirds the amount of dissolved substances as that in the roots. In another plant, *Colocasia antiquorum*, a similar distribution was observed, and it is interesting to note that the droplets of liquid transpired from the tips of the leaves consisted not of sap, but of practically pure water.

These results, as regards the greater concentration of the sap in the roots, are certainly contrary to what I would have expected, but Professor Dixon's experiments are most lucidly described, bear evidence of careful execution, and seem to me quite convincing The Rev. W. B. Clarke,† without giving his authority, states his belief that it had been ascertained that the specific gravity of

* Transpiration and ascent of Sap in Plants, 1914, p.11.

† *Loc. cit.*, p.187.

the sap is least in the roots. This would be a most interesting subject for further observation. It will be noticed that, in the Red Mallee water, the proportions of soda and of chlorine are high relative to the other ingredients. In a series of analyses of Mallee soils published many years ago by the Agricultural Chemist of Victoria,† the amounts of soda and of chlorine vary within wide limits, the chlorine in one case rising as high as 0·20 per cent. of the soil. This corresponds to about 0.33 per cent. of sodium chloride, which is a high percentage for a soil, and is quite sufficient to account for the large proportion of soda and chlorine in the Mallee root-water.

Not all samples of sap obtained in the manner of the Mallee root-water are so dilute; Smith, for instance,‡ found enormously greater amounts of both mineral and organic solids in the sap from the timber of *Grevillea robusta,* while the juices of such plants as the sugar-cane and sugar-maple, carry large percentages of sugar, though not of mineral constituents; it must, however, be remembered that in the case of these latter plants the sweet sap is contained in special cells or vessels, and is not the ordinary circulating sap, but apparently functions as a food reserve. In the specimen of these roots exhibited by Mr. Fletcher, the cut ends showed a remarkable assemblage of open vascular tubes, reminding one strongly of a section of cane. From a consideration of the circumstances, I am inclined to think that the Mallee root-water may be a reserve supply for the use of the plant during droughty conditions stored in special vessels.

† Report Dept. of Agriculture, Victoria, 1875.

‡ Proc. Roy. Soc. N. S. Wales, 1896, p. 194.